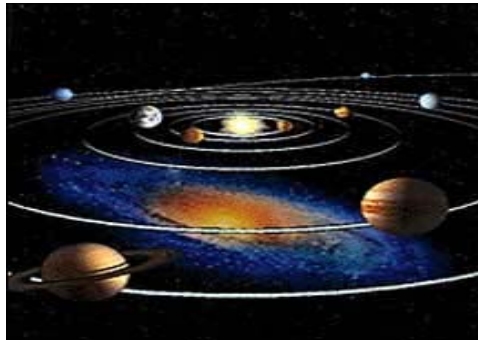
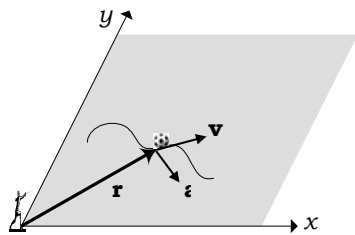


(Plane Motion)



1-3



(1-3)

2-3

(1-3)

a **v** **r**

() oy () ox

(1-3)

$$\begin{cases} \mathbf{r} = x\mathbf{i} + y\mathbf{j} \\ \mathbf{v} = v_x\mathbf{i} + v_y\mathbf{j} \\ \mathbf{a} = a_x\mathbf{i} + a_y\mathbf{j} \end{cases}$$

(2-3)

$$v_y = \frac{dy}{dt} \quad v_x = \frac{dx}{dt}$$

(3-3)

$$a_y = \frac{dv_y}{dt} = \frac{d^2y}{dt^2} \quad a_x = \frac{dv_x}{dt} = \frac{d^2x}{dt^2}$$

1-3

j i $\mathbf{a} = -\mathbf{i} + 2\mathbf{j} \text{ m/s}^2$ $\mathbf{v}_0 = 3\mathbf{i} \text{ m/s}$
 5 s

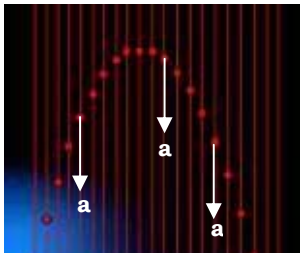
$$\mathbf{v} = \mathbf{a}t + \mathbf{v}_0 = (-\mathbf{i} + 2\mathbf{j})t + 3\mathbf{i} = (-t + 3)\mathbf{i} + (2t)\mathbf{j} \text{ m/s}$$

$$\mathbf{r} = \frac{1}{2}\mathbf{a}t^2 + \mathbf{v}_0t + \mathbf{r}_0 = \frac{1}{2}(-\mathbf{i} + 2\mathbf{j})t^2 + (3\mathbf{i})t + 0 \text{ m}$$

$$\mathbf{r}_0 = (0, 0)$$

$$\mathbf{v}(5) = -2\mathbf{i} + 10\mathbf{j} \text{ m/s} \quad : \quad t = 5 \text{ s}$$

$$\mathbf{r}(5) = 2.5\mathbf{i} + 25\mathbf{j} \text{ m}$$



(Projectile Motion)

3-3

:

:

(4-3) $\mathbf{a} = \mathbf{g} = -g\mathbf{j} \text{ m/s}^2$

()

:

(5-3) $a_y = -g \quad a_x = 0$

:

(6-3)
$$\begin{cases} v_x = a_x t + v_{0x} = v_{0x} \\ v_y = a_y t + v_{0y} = -gt + v_{0y} \end{cases}$$

oy ox

$v_{0y} \quad v_{0x}$

() ()

:

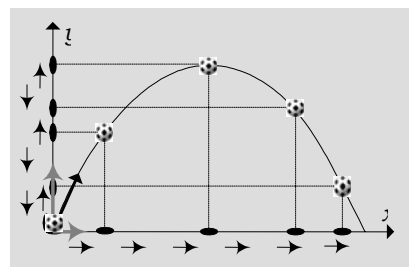
(7-3)
$$\begin{cases} x = \frac{1}{2} a_x t^2 + v_{0x} t + x_{0x} = v_{0x} t + x_{0x} \\ y = \frac{1}{2} a_y t^2 + v_{0y} t + y_0 = -\frac{1}{2} g t^2 + v_{0y} t + y_0 \end{cases}$$

(0,0)

(x_0, y_0)

v_0

(2-3)



(2-3)

x

(8-3)

a_x

v_x

t

$a_x=0$

3-3

oy

.v_{ox}

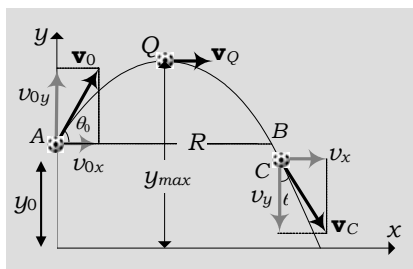
y

) -g

(6-3) (5-3)

v_y

(



(2-3)

(3-3)

: (3-3)

v_{oy} v_{ox}

(8-3)

$$\begin{cases} v_{0x} = v_0 \cos \theta_0 \\ v_{0y} = v_0 \sin \theta_0 \end{cases}$$

:

(9-3)

$$\begin{cases} v = \sqrt{v_x^2 + v_y^2} \\ \tan \theta = \frac{v_y}{v_x} \end{cases}$$

v_y

:(6-3)

$$v_y = -gt_{\max} + v_{oy} = 0$$

(10-3)

$$t_{\max} = \frac{v_{oy}}{g} = \frac{v_o \sin \theta}{g}$$

:(7-3) t_{\max}

$$y_{\max} = -\frac{1}{2}gt_{\max}^2 + v_{0y}t_{\max} + y_0$$

(11-3)

$$y_{\max} = \frac{v_{0y}^2}{2g} + y_0 = \frac{v_0^2 \sin^2 \theta_0}{2g} + y_0$$

:(7-3)

(12-3)

$$y = -\left(\frac{g}{2v_0^2 \cos^2 \theta_0}\right)x^2 + (\tan \theta_0)x + y_0$$

$$y = ax^2 + bx + c$$

.(11-3)

(3-3)

Q

:(range)

:(12-3)

$$y=y_0$$

AB

(3-3)

(13-3)

$$R = \frac{2v_{0x}v_{0y}}{g} = \frac{2v_0^2 \sin \theta_0 \cos \theta_0}{g} = \frac{v_0^2 \sin 2\theta_0}{g}$$

()

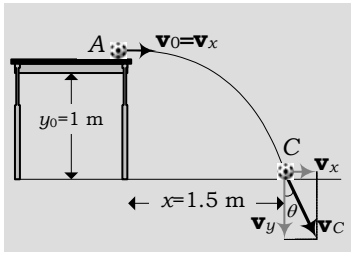
1.5 m

1 m

()

2-3

() .(4-3)



(4-3)

(4-

$$\theta_0 = 0$$

$$y_0 = 1 \text{ m} \quad x_0 = 0 \quad (3)$$

$$v_{0y} = 0 \quad v_{0x} = v_0$$

()

$$x = 1.5 \text{ m}$$

: (7-2)

$$y = 0$$

$$x = v_{0x}t + x_0 = v_0t$$

$$y = -\frac{1}{2}gt^2 + v_{0y}t + y_0 = -\frac{1}{2}gt^2 + 1 = 0$$

:

$$v_0 = 3.3 \text{ m/s} \quad t = 0.45 \text{ s}$$

(6-3)

t

()

:

$$v_x = v_{0x} = 3.3 \text{ m/s}$$

$$v_y = -gt + v_{0y} = -4.4 \text{ m/s}$$

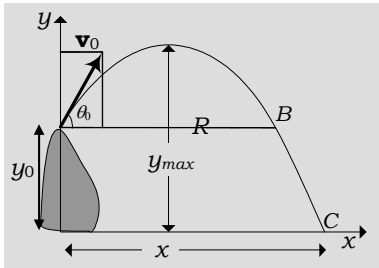
$$\mathbf{v} = v_x \mathbf{i} + v_y \mathbf{j} = 3.3 \mathbf{i} - 4.4 \mathbf{j} \text{ m/s}$$

$$v = \sqrt{v_x^2 + v_y^2} = 5.5 \text{ m/s}$$

:

$$\tan \theta = \frac{v_y}{v_x} = \frac{-4.4}{3.3} = -1.3 \Rightarrow \theta = -53^\circ$$

3-3



(5-3)

300 m
 : . 30° 20 m/s

(5-3)

$$x_0 = 0, y_0 = 300 \text{ m}, v_0 = 20 \text{ m/s}, \theta_0 = 30^\circ$$

$$y = -\left(\frac{9.8}{2(20)^2 \cos^2 30^\circ}\right)x^2 + (\tan 30^\circ)x + 300 = -0.016x^2 + 0.58x + 300$$

: (11-3)

$$y_{\max} = \frac{v_{0y}^2}{2g} + y_0 = \frac{v_0^2 \sin^2 \theta_0}{2g} + y_0 = 305.1 \text{ m}$$

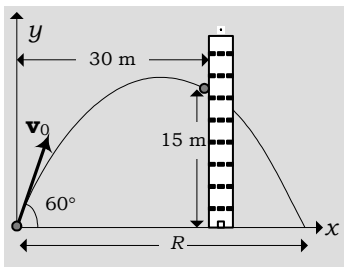
: $y = y_0$

$$300 = -0.016x_B^2 + 0.58x_B + 300 \Rightarrow x_B = R = 36.2 \text{ m}$$

:(12-3) $y=0$

$$y = -0.016x^2 + 0.58x + 300 = 0 \Rightarrow x = 156.2 \text{ m}$$

4-3



(6-3)

60°
 15 m 30 m

() .(6-3)

$$x_0 = y_0 = 0$$

4-3

:

$$x_0 = 30 \text{ m}, \quad y = 15 \text{ m}$$

$$15 = -\left(\frac{9.8}{2v_0^2 \cos^2 60^\circ}\right)(30)^2 + (\tan 60^\circ)(30) + 0$$

$$v_0 = 21.8 \text{ m/s}$$

$$: \quad (11-3)$$

$$y_{\max} = \frac{v_{0y}^2}{2g} + y_0 = \frac{v_0^2 \sin^2 \theta_0}{2g} = 18.3 \text{ m}$$

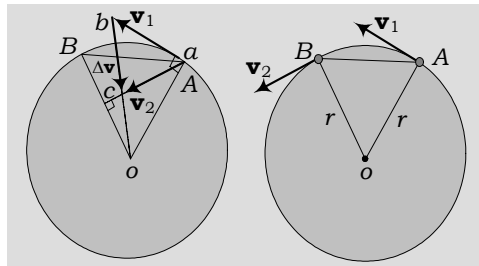
(Uniform Circular Motion)

4-3

r

(7-3)

$$|\mathbf{v}_1| = |\mathbf{v}_2| = v$$



(7-3)

$B \quad A$

Δt

:

$$\mathbf{a}_{av} = \frac{\Delta \mathbf{v}}{\Delta t} = \frac{\mathbf{v}_2 - \mathbf{v}_1}{\Delta t}$$

(7-3)

$\Delta \mathbf{v} \quad \mathbf{a}$

$.B$

A

\vec{ac} Δs AB (7-3) $\Delta v/\Delta t$
 \hat{bac} \hat{AOB} Δv bc v_2
 abc OAB

$$\frac{\overline{AB}}{\overline{bc}} = \frac{\overline{OA}}{\overline{ac}} \Rightarrow \frac{\Delta s}{\Delta v} = \frac{r}{v}$$

$$a_{av} = \frac{\Delta v}{\Delta t} = \left(\frac{\Delta s}{\Delta t}\right)\left(\frac{r}{v}\right)$$

$\Delta v/\Delta t$ Δt B A
 v $\Delta s/\Delta t$ a

(14-3) $a_c = \frac{v^2}{r}$

v^2 / r v r

$2\pi r$ T (period)
 $:$ v

(15-3) $T = \frac{2\pi r}{v}$

f (frequency)
 $:$

(16-3) $f = \frac{1}{T} = \frac{v}{2\pi r}$

$1 \text{ Hz} = 1 \text{ s}^{-1}$ (Hz) $1/\text{s}$

4-3

(angular velocity)

Δt

$\Delta \theta$

(17-3)

$$\omega = \frac{\Delta \theta}{\Delta t}$$

.rad/s

rev/min

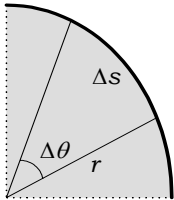
2π

(rev)

rev/min = $2\pi/60$ rad/s :

60

(min)



(8-3)

Δt

ω

v

(8-3)

$$\Delta s = r\Delta\theta$$

$$\omega = \Delta\theta / \Delta t \quad v = \Delta s / \Delta t$$

(18-3)

$$v = r\omega$$

5-3

29.5

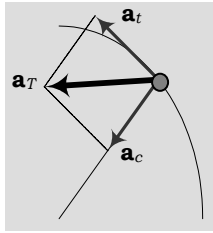
385,000

$$s = 2\pi R = 2\pi(385 \times 10^6) = 2.4 \times 10^9 \text{ m}$$

$$T = 29.5 \times 24 \times 3600 = 2.5 \times 10^6 \text{ s}$$

$$v = \frac{s}{T} = \frac{2.4 \times 10^9}{2.5 \times 10^6} = 9.6 \times 10^2 \text{ m/s}$$

$$a = \frac{v^2}{r} = \frac{(9.6 \times 10^2)^2}{385 \times 10^6} = 2.4 \times 10^{-3} \text{ m/s}^2$$



(9-3)

$$a_t = dv/dt \quad (\text{tangential acceleration})$$

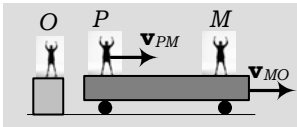
$$(9-3) \quad a_c = v^2 / r \quad (\text{central acceleration})$$

(19-3)

$$\mathbf{a}_T = \mathbf{a}_t + \mathbf{a}_c$$

(20-3)

$$a_T = \sqrt{a_t^2 + a_c^2}$$



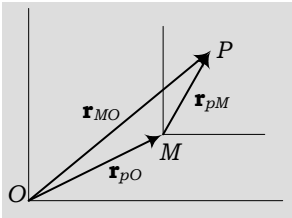
(10-3)

5 m/s
3 m/s

(Relative Velocity)

5-3

(10-3)



(11-3)

$$5 + 3 = 8 \text{ m/s} \quad (\quad)$$

$$.5 + (-3) = 2 \text{ m/s}$$

(21-3)

$$\mathbf{r}_{PO} = \mathbf{r}_{PM} + \mathbf{r}_{MO}$$

\mathbf{r}_{PM} O M \mathbf{r}_{MO} O P \mathbf{r}_{PO}

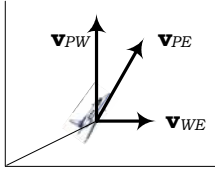
(11-3)

(22-3)

$$\mathbf{v}_{PO} = \mathbf{v}_{PM} + \mathbf{v}_{MO}$$

. M P \mathbf{v}_{PM} O M P \mathbf{v}_{MO} \mathbf{v}_{PO}

200 km/h



(12-3)

$\mathbf{v}_{WE}=100$

(12-3)

$\mathbf{v}_{PW}=200 \mathbf{j}$ (km/h)
 \mathbf{i} (km/h)

$\mathbf{v}_{PE} = \mathbf{v}_{PW} + \mathbf{v}_{WE} = 100\mathbf{i} + 200\mathbf{j}$ km/h

$v_{PE} = \sqrt{(100)^2 + (200)^2} = 223$ km/h

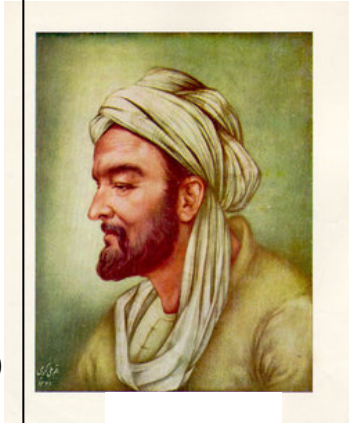
$\tan \theta = \frac{200}{100} \Rightarrow \theta = 63^\circ$

980)

.(1036

() ()

. 1500 -1100



$$\left. \begin{aligned}
 a_y &= -g \quad , \quad a_x = 0 \\
 v_x &= v_{0x} = v_0 \cos \theta_0 \\
 v_y &= -gt + v_{0y} = -gt + v_0 \sin \theta_0 \\
 x &= v_{0x}t + x_0 \\
 y &= -\frac{1}{2}gt^2 + v_{0y}t + y_0
 \end{aligned} \right\}$$

$$y_{\max} = \frac{v_{0y}^2}{2g} + y_0 = \frac{v_0^2 \sin^2 \theta_0}{2g} + y_0$$

$$R = \frac{2v_{0x}v_{0y}}{g} = \frac{2v_0^2 \sin \theta_0 \cos \theta_0}{g}$$

$$y = -\left(\frac{g}{2v_0^2 \cos^2 \theta_0}\right)x^2 + (\tan \theta_0)x + y_0$$

$$a = v^2 / r$$

$$T = \frac{1}{f} = \frac{2\pi r}{v}$$

$$\omega = \Delta\theta / \Delta t$$

$$v = r\omega$$

$$\mathbf{v}_{PO} = \mathbf{v}_{PM} + \mathbf{v}_{MO}$$

.6 s 25 m/s 90° **1-3**

$\mathbf{r}_0=0$ $\mathbf{a} = \mathbf{i} - 4\mathbf{j} \text{ m/s}^2$ **2-3**

2 s $.3\mathbf{i} + 2\mathbf{j} \text{ m/s}$ $t=0$

t r $\mathbf{r} = (6 + 2t^2)\mathbf{i} + (3 - 2t + 3t^2)\mathbf{j}$ **3-3**

$t=2 \text{ s}$

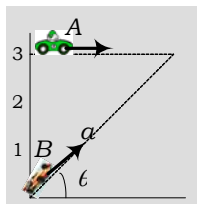
$\mathbf{r} = (2t^3 - 3t^2)\mathbf{i} + (t^2 - 2t + 1)\mathbf{j}$ **4-3**

() $t=1 \text{ s}$ () . t r

$t=0$

$5.6\mathbf{i} + 7.1\mathbf{j}$ m/s $3.6\mathbf{i} - 2.9\mathbf{j}$ m/s **5-3**

$\mathbf{v}_0 = 6.3\mathbf{i} - 8.4\mathbf{j}$ m/s **6-3**



3 m/s $y=3$ A **7-3**
 B $x=0$
 ox θ 4 m/s^2 O
 A B θ $.(13-3)$

(13- $x=t^2$ **8-3**

() $y=(t-1)^2$

$t=1$ s 5 m/s ()

$y=A\sin\omega t$ $x=A\cos\omega t$ **9-3**

$\mathbf{a} = -\mathbf{i} - 0.5\mathbf{j}$ m/s² $t=0$ **10-3**

$\mathbf{v}_0 = 3\mathbf{i}$ m/s

30° 100 m/s h **11-3**

1000 m

30 m/s 1 m **12-3**

$x=20$ m 37°

10 km 500 km/h **13-3**

() .3 m/s 1 m **14-3**

.45 s 46 m **15-3**

1 m

10 m

60 m

60°

16-3

100 m/s

50 m

17-3

1 m

150 m/s

45°

19.6 m/s

18-3

55 m

9.1 m

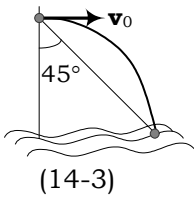
$7.6\mathbf{i} + 6.1\mathbf{j}$ m/s

19-3

20-3

21-3

1/6



() .

40 m

22-3

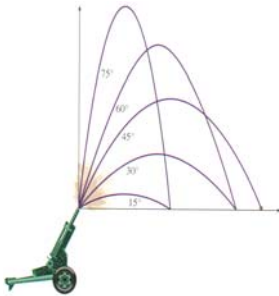
()

() (14-3)

45°

.h

23-3



24-3

45°

\mathbf{v}_0

25-3

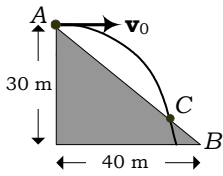
() R

30°

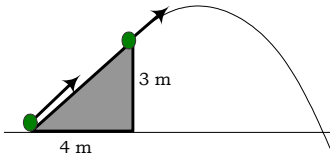
100 m/s

250 m

26-3



(15-3)



(16-3)

10 m/s

27-3

.(15-3)

:

.)

AB

37°

28-3

0.6 s

10 m/s

.(16-3)

30 m/s

1 m

29-3

75 m

$.30^\circ$

.180 m

45°

30-3

87 km/h

"

"

31-3

()

() $.45^\circ$

() .630 m/s

32-3

()

700 m

150 m

110 km/h

33-3

x $.x$

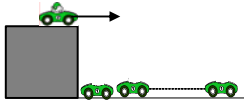
$.9.8728 \text{ m/s}^2$

70 m

34-3

9.7967 m/s^2

35-3



(17-3)

2 m

.(17-3)

2.4 m

36 m

36-3

6.4 m

:

37-3

1.5×10^{11} m

38-3

24 15 m

2 m

39-3

.10 m

1.5 m

4 m/s

2 m

40-3

0.6 m

41-3

2.4 m/s²

42-3

5×10^{-11} m

43-3

$.9 \times 10^{22}$ m/s²

1/10

44-3

20 g

90°

640 km

45-3

6400 km

98

.2 s 60 cm

46-3

48 cm

20 m/s 200 m

47-3

.1 m/s²

30 m

48-3

8 m/s²

	300 km/h		49-3
		100 km/h	
30°			50-3
	.10 m/s		
	.240 km/h		51-3
	40 km	150 km	
	120 km/h		
	60 s	(escalator)	52-3
		90 s	
	.330 m/s		53-3
		30 m/s	
.12 m/s		0.5 m/s	54-3
25 km/h	50°	10 km/h	55-3
			10°
5 m/s		4 m/s	56-3
() .90 km/h		5 m	57-3
	()		